

GEOTHERMAL ENERGY RESOURCES IN ALBANIA

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ABSTRACT

Geothermal energy of low enthalpy sources in Albania are presented in the paper. Geothermal sources in Albanian are located in three geothermal zones:

- **Kruja geothermal zone**, with an identifiable resources 5.9×10^8 - 5.1×10^9 GJ in carbonate reservoirs.
- **Ardenica geothermal zone** in sandstone reservoirs, and
- **Peshkopia gjeothermal zone**, where the springs are linked with the disjunctive tectonic seismic-active zone.

The geothermal situation of low enthalpy in Albania, offers three domains for the direct use of geothermal energy:

First, geothermal heat pump system for space heating and cooling.

Second, thermal waters of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a complex and cascade direct use of energy.:

Third, the use of deep abandoned oil and gas wells as “Vertical Earth Heat Probe”.

KEYWORDS: Geothermal energy, geothermal regime, heat flow density, low enthalpy, thermal water, direct use.

1. INTRODUCTION

Paper represents a summary of the important results of the geothermal studies and projects in Albania, performed in the framework of the National Program for Research and Developing, Water & Energy (1993-1997, 2003-2005, 2007-2009), agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects [1, 2, 3, 4, 5, 7, 10, 11, 12].

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

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2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big pelegeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin, continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonatic formation of the Upper Triassic-Eocene. The geological section on this carbonatic formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schlieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasse of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonatic neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, over thrust and over twisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated [2, 4]. Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1. Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location [1, 2, 4].

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth vary from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1,2). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the centre of the Peri-Adriatic Depression and even further towards the north-western coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 mK.m⁻¹ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the centre of Pre-Adriatic Depression (Fig. 3). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 mK.m⁻¹ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones.

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 mK.m⁻¹ at north-eastern and south-eastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 4):

Firstly, maximal value of the heat flow is equal to 42 mW/m² in the center of Peri-Adriatic Depression of External Albanides. The 30 mW⁻² value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m². The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.5). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 5)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 5):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Permet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are 5.9x10⁸-5.1x10⁹ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal

Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m².

Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with as length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

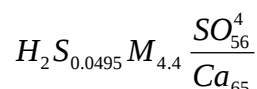
In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them. Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320° azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l.

Peshkopia gjeotermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age, that has penetrated Eocenic flysch, which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H₂S. Their chemical formula is:



Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

Water temperature and big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana- Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Table 1. Thermal water springs in Albania

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Lëngarica-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10
9	Steam Postenani springs			

Table 2. The oil and gas wells that have self-discharge of the thermal water

N°	Well Name	Temperature in °C	Salt in mg.l ⁻¹	Self-discharge in l.sec ⁻¹
1	Kozani	65.5	4.6	10.4
2	Ishmi	64	19.3	4.4
3	Galigati	45-50	5.7	0.9
4	Bubullima	48-50	35	
5	Ardenica	38		15-18
6	Ardenica	32		
7	Semani	35		5
8	Verbasi	29.3		1-3



Photo 1. Lëngarica-Permeti thermal water springs



Photo 2. Geothermal deep well Kozani - 8

5. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy [2, 6, 7, 8, 9, 10, 11, 12].

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari mountain or Ohrid Lake pearl.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near of the old road "Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skenderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must be en good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 mK·m⁻¹. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells, can be build greenhouses.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern

technologies for a complex and cascade exploitation of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.
2. Resources of the geothermal energy in Albania are;
 - a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
 - b) Heat of subsurface ground, with an average temperature of 16.4°C and depth Earth Heat Flow.
3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

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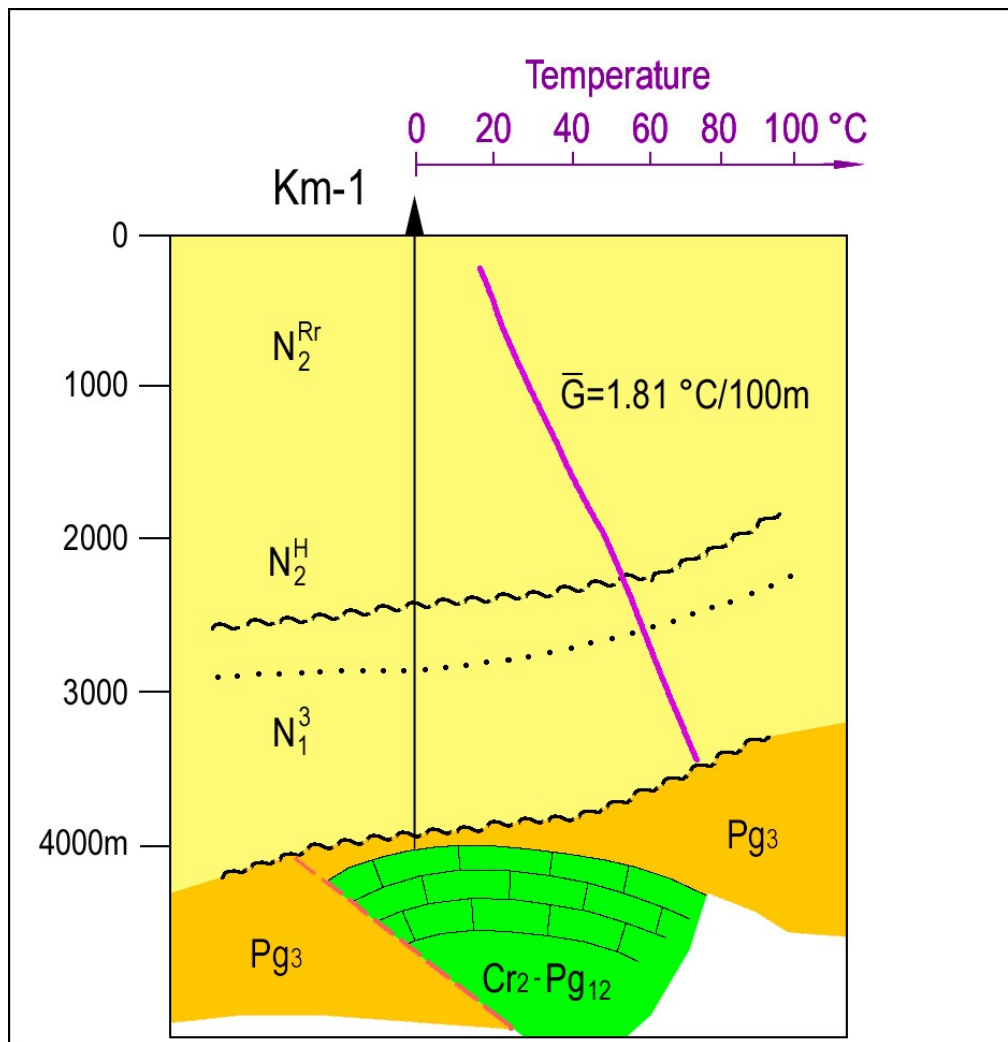


Fig. 1 - Geothermal Section Peri-Adriatic Depression

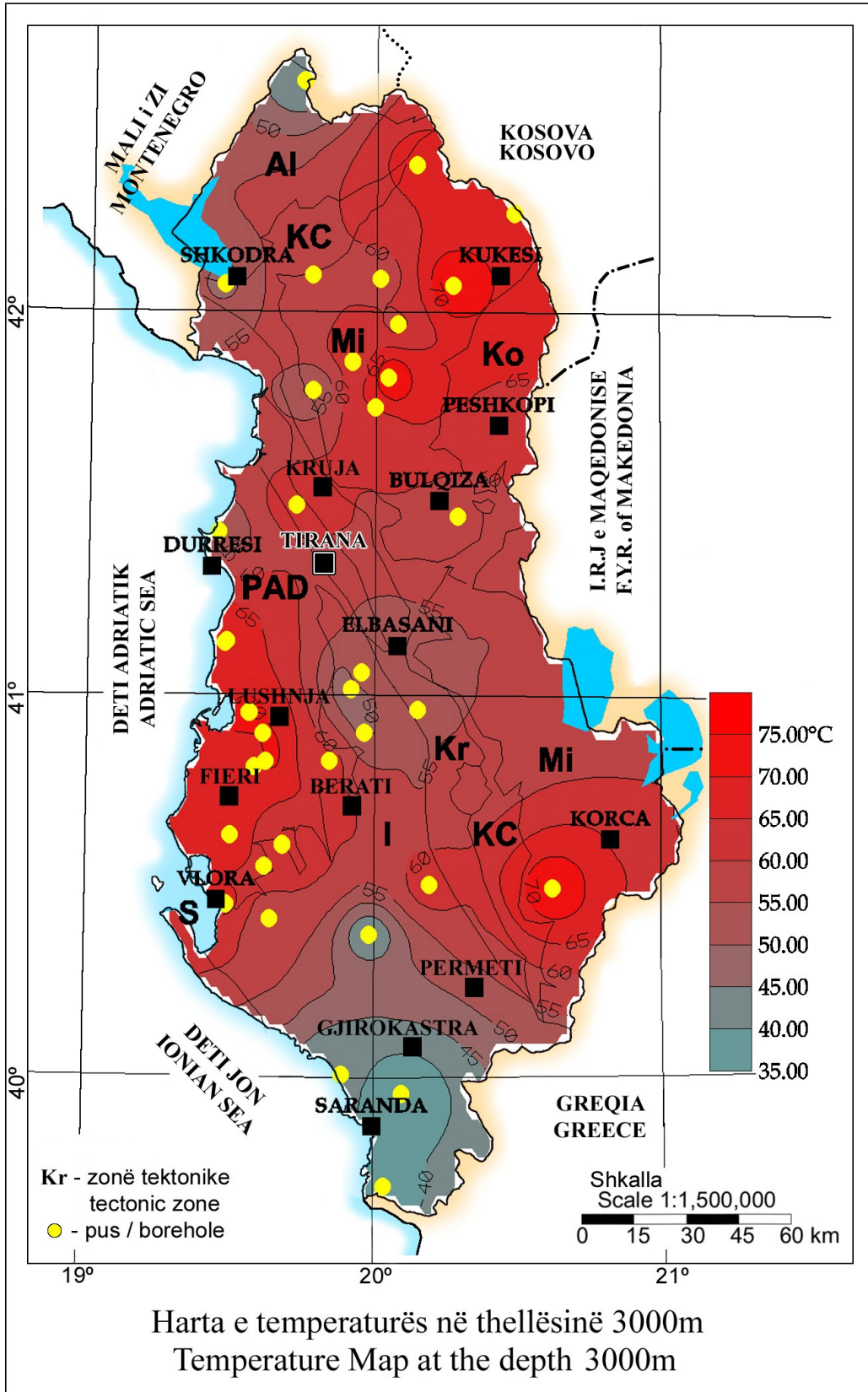


Fig. 2

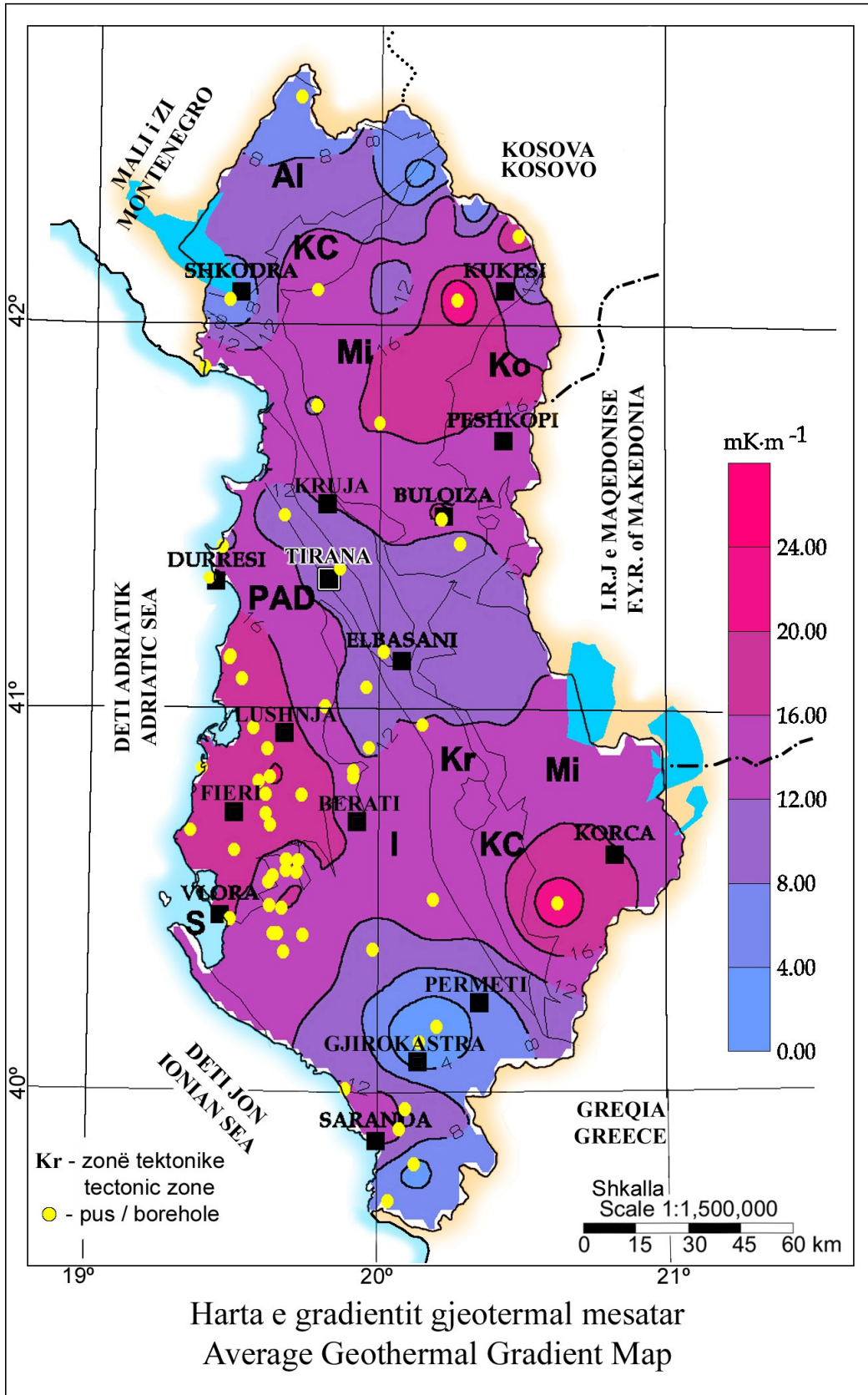


Fig. 3

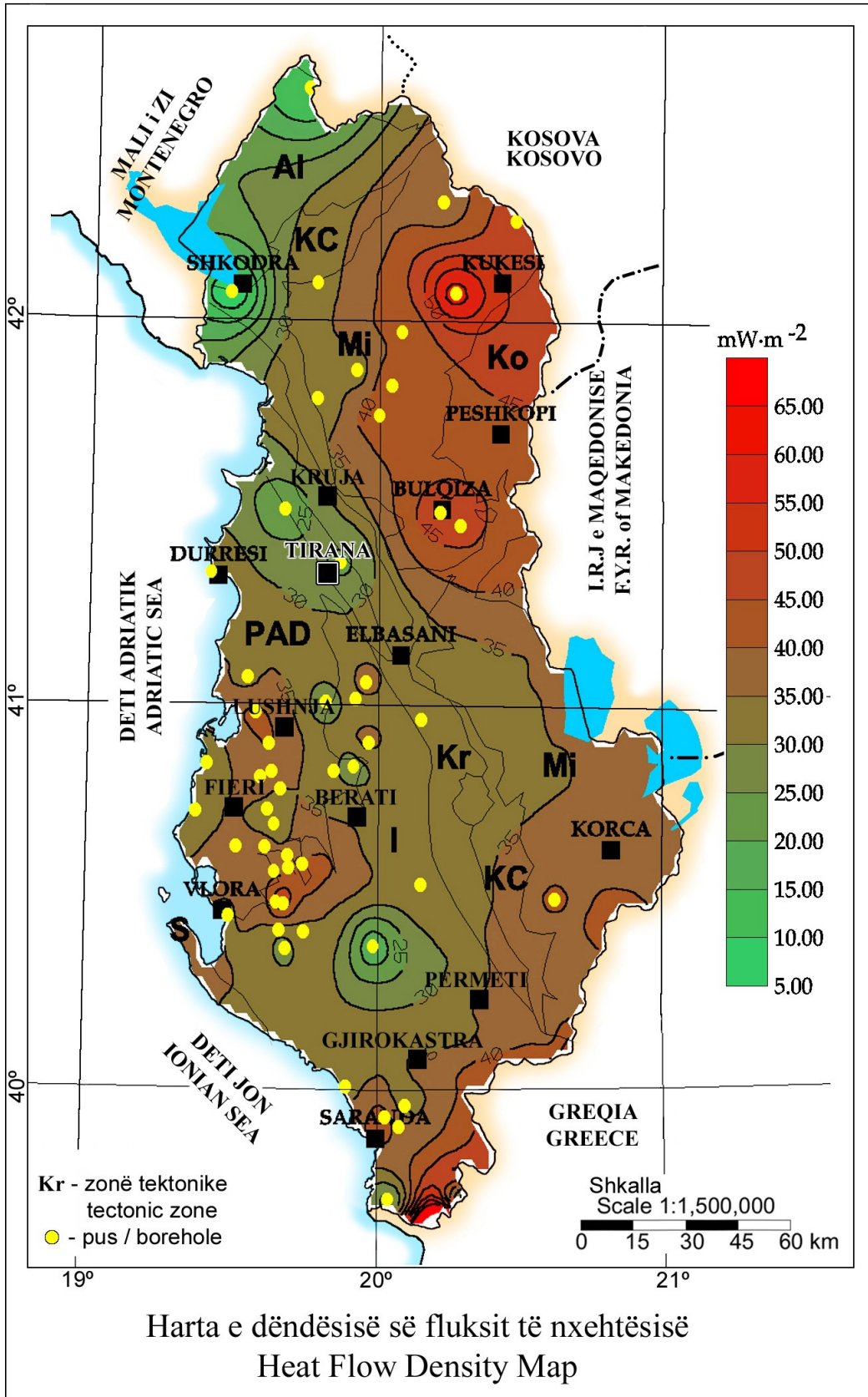


Fig. 4

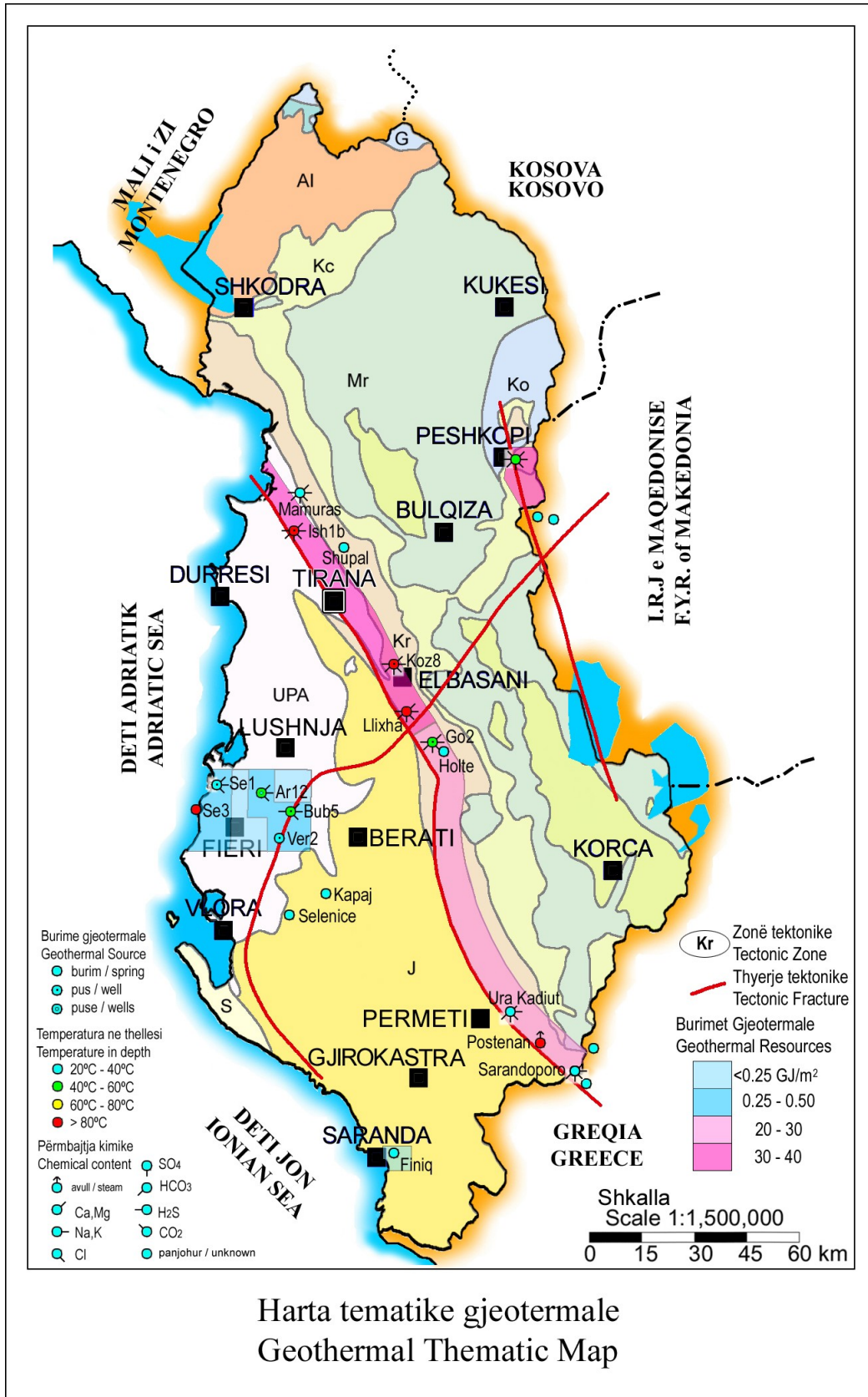


Fig. 5